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National Aeronautics and Space Administration

QuEST

Qualifying Environmentally Sustainable Technologies

July 2007 Volume 2

Message from the Program Manager

As time passes, things must evolve. So it is with NASA and the NASA Acquisition Pollution Prevention (AP2) Office. The AP2 Office initially focused on pollution prevention as our primary means of supporting the mission, but our experience has given us the opportunity to expand beyond that.

The AP2 Office provides information management and technology evaluation and implementation while assisting with regulatory support. We work within the Agency and with the Department of Defense, industry and international partners to promote more efficient systems and processes while ensuring the health and safety of people, assets, and the environment.

To reflect the true nature of the work we perform, the AP2 Office has changed its name to the NASA Technology Evaluation for Environmental Risk Mitigation Principal Center (TEERM). The new name indicates the purpose of the office (Environmental Risk Mitigation), not just pollution prevention, and how we accomplish that goal (Technology Evaluation).

This is the beginning of a new era for our office; one which I know will benefit the Agency and our partners. Thank you for your continued support.

Christina Brown
TEERM Principal Center Manager
NASA KSC/KT-F

Supporting the NASA Mission through Risk Mitigation

The mission of the TEERM Principal Center is:

To identify and validate environmental technologies through joint activities that enhance mission readiness and reduce risk while minimizing duplication and associated costs.

That purpose gives TEERM a vital role in supporting the NASA Mission "to research, develop, verify, and transfer advanced aeronautics and space technologies."

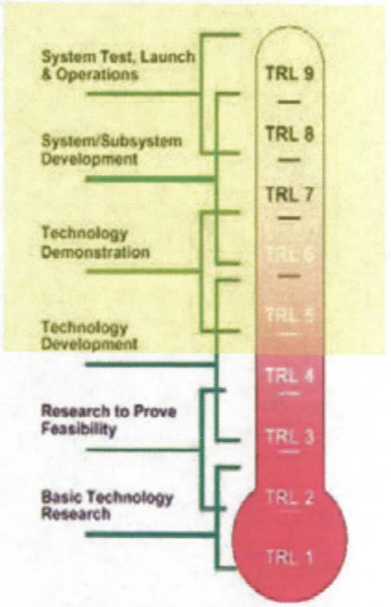
Validation of Technologies

TEERM focuses its validation efforts on technologies that have shown promise in laboratory testing, but lack testing under realistic or field environment. Mature technologies have advantages over those that are still in the developmental stage such as being more likely to be transitioned into a working environment.

One way TEERM begins to evaluate the suitability of technologies is through Technology Readiness Levels (TRLs). TRLs are a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. TEERM generally works on demonstrating/validating alternatives that fall within TRLs 5-9.

In instances where a mature technology does not exist for a particular Agency application, TEERM works with technology development groups and programs such as NASA's Innovative Partnerships Program (IPP). The IPP's purpose is to identify and document available technologies in light of NASA's needs, evaluate and prioritize those technologies, and reach out to find new partners.

All TEERM projects involve multiple partners. Partnering reduces duplication of effort that otherwise might occur if individuals worked their problems alone. Partnering also helps reduce individual contributors' shares of the total cost of technology validation. Through



NASA Technology Readiness Levels that TEERM focuses on

collaboration and financial commitment from project stakeholders and third-party sources, it is possible to fully fund expensive demonstration/validation efforts.

Enhancing Mission Readiness and Reducing Risk

While validating environmentally friendly alternatives, the goal of TEERM is to also improve mission readiness and reduce risk to personnel and assets. TEERM accomplishes this by addressing material obsolescence concerns, environmental liability, and safety issues while reducing costs associated with testing, decreasing production time, and costs.

The aerospace industry, and especially NASA, comprises only a small portion of the worldwide market making NASA particularly susceptive to supply problems. The burden of compliance from environmental regulations causes some manufacturers to stop producing affected products resulting in a material obsolescence issue; examples include lead in electronics and hexavalent chrome (Hex Cr).

The European Union and other governments have passed laws restricting the use of lead (and certain other hazardous substances) in electronics. While such laws seemingly do not affect the U.S., they will in fact result in most parts being manufactured lead-free worldwide because it makes little sense for manufacturers to make lead-free components only for the U.S. The risk of receiving contaminated parts is an issue because the reliability of lead-free is not known in the harsh environments experienced by NASA and the DoD.

The Occupational Safety and Health Administration recently lowered the Permissible Exposure Limit for Hex Cr affecting various operations including coating and plating. There are concerns that Hex Cr containing products will no longer be produced or that suppliers will no longer be able or willing to use it due to increased requirements. Hex Cr is a valuable component in corrosion protection and finding a suitable alternative is imperative for protection of valuable assets.

While it may seem that environmentally driven alternatives only help with regulatory compliance, many actually improve the process and enhance mission readiness as well. For example, many depainting media alternatives are recyclable thus reducing costs along with waste and may even increase productivity. Increased productivity means reduced labor costs and time required between launches.

Both new and legacy programs can benefit from implementation of novel materials and processes. History has shown that environmental regulations are seldom rolled back or become less restrictive over time, but instead become more stringent and encompassing. For this reason, the principles by which TEERM abides by are fully applicable to current and future NASA programs.

Coating Removal Projects

TEERM has several projects that focus on coating removal for various applications including structures, Ground Support Equipment (GSE), and Shuttle. Alternative materials and processes are selected with the goal of improving corrosion protection, facilitating easier maintenance activities, extending maintenance cycles, eliminating flight hardware contamination, and reducing particulate matter emissions and wastes that are hazardous to personnel and the environment.

Low-Emission Depainting

TEERM partnered with Kennedy Space Center (KSC), Stennis Space Center (SSC), Glenn Research Center (GRC), and AFSPC to identify, evaluate, and approve alternative surface preparation technologies for structural steel applications. Approved alternatives will reduce risks associated with particulate matter emissions and hazardous waste. Field evaluations were conducted at GRC on ground support equipment and on facilities at SSC. Test panels were also prepared for laboratory evaluation.

Based on the testing results, three abrasive media technologies were identified as viable alternatives for large area depainting. Mechanical removal with vacuum attachments was determined to be an acceptable alternative for hand tooling.

Depainting PPOA for CCAFS

TEERM conducted an assessment of the risks and opportunities of the current structures maintenance activities at Cape Canaveral Air Force Station (CCAFS), FL. An emphasis was placed on reducing the risks associated with particulate matter emissions and hazardous waste, while improving down-times and increasing mission readiness. The results of previous studies (including TEERM's Low Emission Depainting Project) were used in recommending viable depainting alternatives. These findings helped the AFSPC select depainting technologies for use in a follow-on depainting demonstration at CCAFS in early 2007.

Portable Laser Depainting Demo

TEERM has been following the work of the Joint Group on Pollution Prevention (JG-PP) to demonstrate and validate a coating removal system using a portable laser coating removal system (PLCRS). PLCRS removes coatings with minimal environmental and safety impact, and there are no harmful chemicals to purchase, store, and dispose of. Based on that previous work, a joint study with United Space Alliance (USA),

CCAFS Launch Complex 17

2006 C3P/NASA Workshop

This year, the Centro Para Prevenção da Poluição (Portuguese Center for Pollution Prevention or C3P) and NASA partnered with Air Force Space Command (AFSPC) to host the 4th Annual International Workshop on Pollution Prevention and Sustainable Development in Colorado Springs, CO, on November 1-2, 2006. The Workshop was held in conjunction with the Air Force Foreman's Meeting and Shuttle Environmental Assurance Initiative bi-annual meeting to maximize the value for participants.

The workshop began with welcoming comments from James Leatherwood, Director of NASA's Environmental Management Division and by General (ret.) Pelagio Castelo Branco, C3P Director General. Mr. Jeffrey S. Ashby, NASA Astronaut and NASA/AFSPC Liaison, provided a slide show of his trips to the International Space Station (ISS) and discussed the importance of partnerships and sustainability. Lt. Col. Shawn Jansen, Director of the Commanders Action Group, HQ AFSPC, also provided a stimulating slide and video overview of AFSPC.

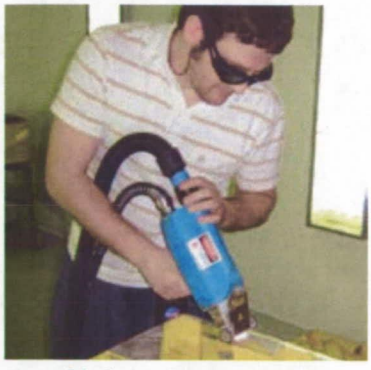
The two-day workshop provided an excellent forum for U.S. and international subject matter experts to showcase innovative and emerging technologies, share lessons learned, and identify new joint opportunities. The Workshop offered two separate tracks, one focusing on pollution prevention and the other on sustainable development and renewable energy. More than 40 international scientists, technologists, and engineering experts gave presentations on topics ranging from advanced coatings and coating removal technologies to green design and alternative energy sources.

Presentations can be found on the TEERM website. The next Workshop is planned for early November 2007 in Lisbon, Portugal.

Mr. Ashby talks about his experiences on the ISS at the 2006 C3P/NASA International Workshop

NASA, and Boeing was conducted to try to further understand the capabilities of PLCRS.

Several NASA Centers participated in an effort to demonstrate the use of hand-held lasers to remove coatings and rust from GSE and structural steel that proved the system's effectiveness. Most notably, it showed excellent potential for implementation for non-destructive evaluation and inspection of weld-lines and for small-area depainting/corrosion removal where blast-media is not permitted.



Portable laser depainting at KSC in Fall 2006

The demonstration also proved that PLCRS can reduce critical GSE down-time thus increasing mission readiness while reducing the risk of contamination that can arise when using some conventional methods of removing coatings.

Coatings Projects

NASA and AFSPC maintain valuable assets, from aircraft made of aluminum and other delicate substrates, to large steel structures that withstand the immense forces of a launch. Protection of these assets can be enhanced through the careful selection and application of coatings.

Non-Chrome Coating Systems

The Non-Chrome Coating Systems for Aircraft and Aerospace Applications project is a coordinated effort by NASA and the Air Force to test alternative non-chrome coating systems. The project aims to qualify a complete coating system that has no Hex Cr in any of the constituent coating layers. The project is looking at various aluminum alloys used on both legacy and future space hardware. The first phase of testing will analyze the corrosion protection properties of chrome-free systems to determine whether they should undergo further, more rigorous testing.

Isocyanate-Free Coating Systems

TEERM partnered with KSC, SSC, and AFSPC to demonstrate and validate alternatives to isocyanate polyurethanes for protecting infrastructure and support equipment. Coatings with isocyanates are completely banned from use at SSC and are strictly controlled at KSC.

Phase II testing of alternatives that passed the Phase I (screening) was completed in late 2006. All of the alternatives were placed at the KSC Corrosion Test Bed for 18-month Marine Exposure. Coatings were also applied to an engine test stand at SSC for field evaluation and inspected at six and 12 months. A Joint Test Report is being prepared. Preliminary results were included in follow-on work such as the Low VOC Coatings and Depainting Field Testing project.

Low VOC Coatings and Depainting

This project is a continuation of previous TEERM and AFSPC work on low emission depainting and coating alternatives. Its purpose is to field demonstrate and qualify alternative surface preparation/depainting processes and low/no VOC, non-hazardous coatings for maintenance operations at CCAFS, FL.

Field demonstrations will occur in early 2007. Depainting alternatives will be tested for their efficiency while controlling labor costs and waste. Coating alternatives will be applied to the structure and left exposed to the elements

Information Exchange

Along with its own testing projects, TEERM also provides information to partners to help them identify products that are more environmentally friendly yet meet performance requirements. One such example is a coating system that was previously tested during the JG-PP's Low/No-VOC and Nonchromate Coating System for Support Equipment project. When SSC contacted TEERM asking for a recommendation of a coating system to be used on the inside of the flame bucket of an engine test stand, TEERM was able to identify a coating system that showed excellent results in corrosion testing and was made for high temperature applications that was ultimately approved and used.

for 18 months to test for corrosion protection. Some of the coatings will also be applied to areas that come in direct contact with the corrosive gases and intense heat from a launch.

Thermal Spray Coating Application at CCAFS

Green Electronics Projects

International directives and marketing forces against lead in electronics are helping drive component and board suppliers to provide lead-free products. Legislative exemptions for high reliability aerospace electronics will not protect these assemblies from the introduction of lead-free.

Parts with pure tin finishes present the most problem for high-reliability users. Electroplated tin is prone to electrical shorting via tin whiskering. The whiskering potential is compounded by the fact that as both lead and lead-free parts enter the market, the risk of cross contamination and mix-ups increases. A few high reliability electronics users and a high profile testing program have already received parts with pure tin finishes even though their procurement contracts prohibited lead-free.

Lead-free Solder Reliability Testing

TEERM recently published a report of the findings from a study by NASA, DoD, and their contractors on the effects of lead-free soldering on the reliability of interconnects in high reliability applications. The results will be used by original equipment manufacturers, suppliers, and system managers as they consider transitioning to lead-free materials in electronic assemblies. The collaborative project was awarded the 2005 Soldertec Global Consortium Award that recognizes significant contributions to the development and implementation of lead-free electronics soldering.

Lead-Free Electronics Testing – Project 2

TEERM launched a second lead-free electronics project in 2006 to study the effects of tin-lead, lead-free, and mixed lead/lead-free rework on solder-joint reliability. Data generated from the project will help in gaining a better understanding of what happens when potentially incompatible solder alloys are inadvertently mixed.

Other Work

Membrane Removal of VOCs

TEERM is identifying processes at NASA and DoD facilities for demonstration of the membrane filter to capture VOCs from contaminated process air streams. Examples include a groundwater remediation site, a painting/coating facility, a fuel tank farm, several precision cleaning facilities, and some laboratories. TEERM will begin testing the membrane technology at U.S. sites in 2007, and is looking at the possibility of demonstrations overseas.

Renewable Energy

TEERM is working a collaborative effort in renewable energies with White Sands Test Facility (WSTF) and C3P. The effort began with a driving need for more electrical energy at WSTF for a groundwater remediation system. Residing in an area with high continuous winds and excellent solar energy potential, WSTF could employ these renewable energy sources to offset utility costs. TEERM's C3P partners are very adept at wind energy and currently have many systems already in operation.

Corrosion Working Group

The NASA Corrosion Technology Laboratory at KSC has created the NASA Corrosion Working Group (NCWG), a forum for Agency-wide cooperation to address corrosion control issues and optimize the use of resources to reduce the impact of corrosion within NASA. The mission of the NCWG is to support NASA's mission of human exploration and scientific discovery by pursuing initiatives and collaborative efforts focusing on the corrosion control needs of all the NASA Centers and facilities. NCWG is a resource to TEERM for information on corrosion prevention, control and mitigation methods, and products.

This is a publication of NASA's Technology Evaluation for Environmental Risk Mitigation Principal Center (TEERM) located at Kennedy Space Center, FL.
For more information, please visit our website at
www.teerm.nasa.gov

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